CAN to 9 Output Valve Controller
P/N: AX021200
12V, 24V, 48V, 72V
CAN (SAE J1939)

with Electronic Assistant® EA

Features:
- Command messages are received through the CAN network (no physical inputs)
- 9 outputs are user selectable from the following (up to a maximum of 7A of controller power supply intake at one time).
  - o   Output Disabled
  - o   Proportional Current
  - o   Hotshot Digital
  - o   On/Off Digital
  - o   Proportional Voltage
  - o   PWM Duty Cycle
- 12V, 24V, 42V, 48V or 72VDC nominal input power
- 1 CAN port (SAE J1939), 1 RS-232 port
- CANopen® module available on request (P/N: AX021201)
- Hardware is also available as a platform for application-specific software
- **Electronic Assistant®** EA runs on a *Windows* operating system for user configuration. An Axiomatic USB-CAN converter links the PC to the CAN bus.
- Rugged IP67 packaging and connectors

Description:
The controller features 1 CAN port for controlling the outputs and diagnostics over the CAN bus. It accepts a wide variety of nominal input power supply voltages (12V, 24V, 42V, 48V or 72VDC). Using the CAN network, it can provide control of up to nine outputs, configured for a wide variety of responses. For example, it can drive proportional valves, on/off valves or provide a hotshot control profile. PWM signal or proportional voltage outputs are also user selectable. Standard software is provided. The sophisticated microprocessor can accommodate complex application-specific control algorithms for advanced machine control on request. Rugged IP67 rated packaging in addition to the wide-ranging power supply input section suits the harsh environment of mobile equipment with on-board battery power. Settings are user configurable via a *Windows*-based Electronic Assistant® configuration tool interfacing to the controller via an USB-CAN device.

Applications:
- Off-highway construction equipment
- Municipal vehicles
- Material handling equipment (forklifts, etc.)

Ordering Part Numbers:

| SAE J1939 version	CANopen® version
Controller: **AX021200** *Contact Axiomatic for a quotation to provide application-specific control logic.*	Controller: **AX021201** EDS File: **EDS-AX021201**
Accessories: **PL-DTM06-12SA-12SB** Mating Plug Kit (no DB-9) (The KIT is comprised of: DTM06-12S, DTM06-12SB, 2 W12S and 24 contacts. The Axiomatic stock # is FG-IOCTRL-19.)	
AX070502 Configuration KIT includes the following. USB-CAN Converter P/N: AX070501 1 ft. (0.3 m) USB Cable P/N: CBL-USB-AB-MM-1.5 12 in. (30 cm)CAN Cable with female DB-9 P/N: CAB-AX070501 AX070502IN CD P/N: CD-AX070502, includes: **Electronic Assistant** AX070500 software; EA & USB-CAN User Manual UMAX07050X; USB-CAN drivers & documentation; CAN Assistant (Scope and Visual) software & documentation; and the SDK Software Development Kit. **NOTE: To order this kit, you need only to specify P/N: AX070502.**	PC-based CANopen Configuration Tool: *Industry standard CANopen PC-based software*

## Block Diagram:
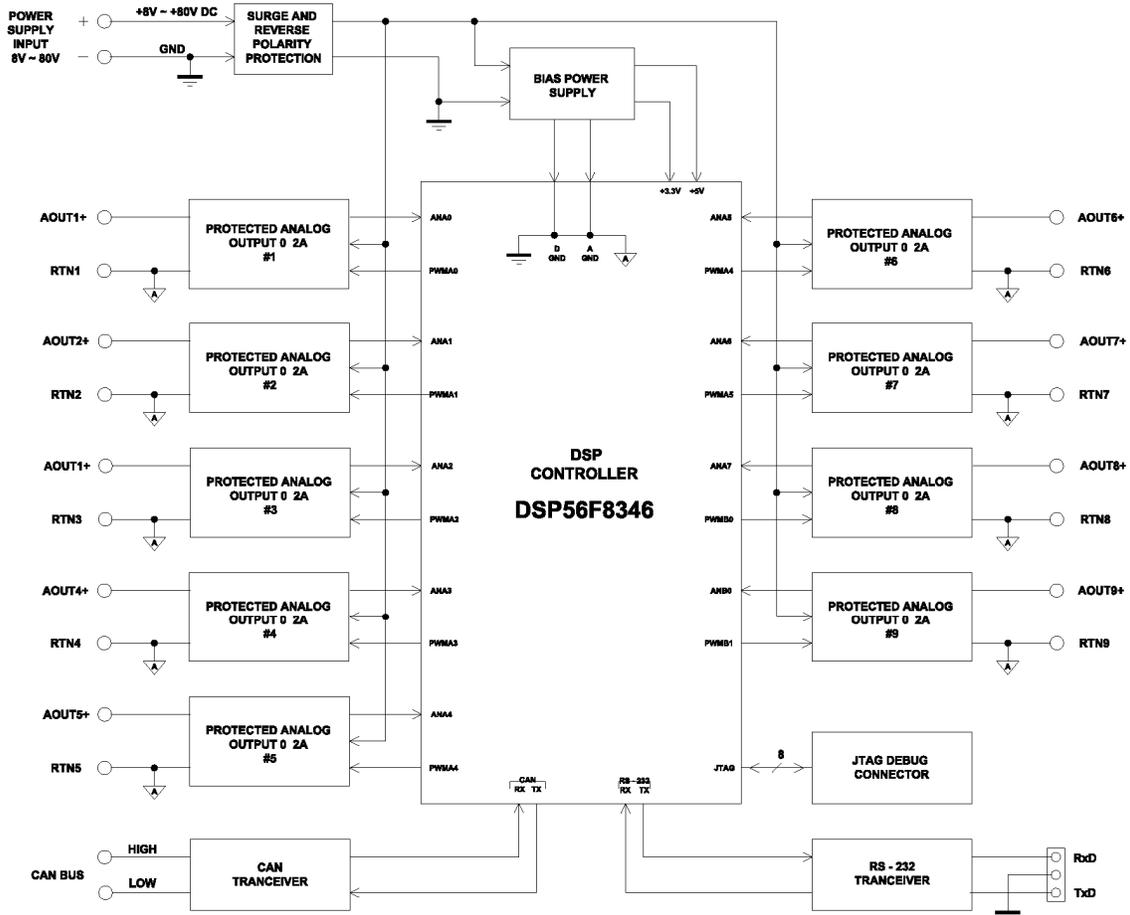
Set up of AX021200 Controller on a CAN Network:
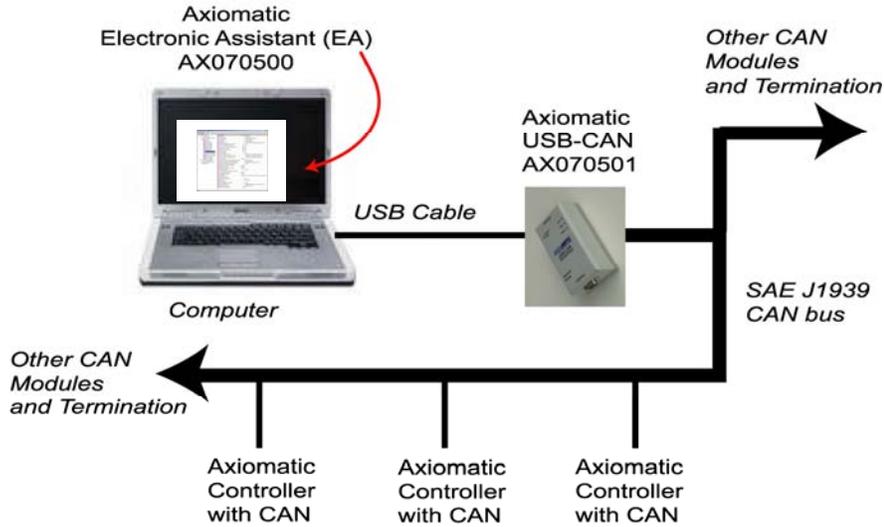
Technical Specifications:
Input Power Supply Specifications

Power Supply Input - Nominal	12V, 24V, 42V, 48V or 72V DC nominal Maximum 80 VDC power supply (8…80VDC) Surge protection is provided. NB. The maximum total current draw permitted on the power supply input pins is 7 Amps @ 24VDC, at one time.
Reverse Polarity Protection	Provided
Input Impedance	400 KOhms

Supply Intake Current vs Total Output Current [A]
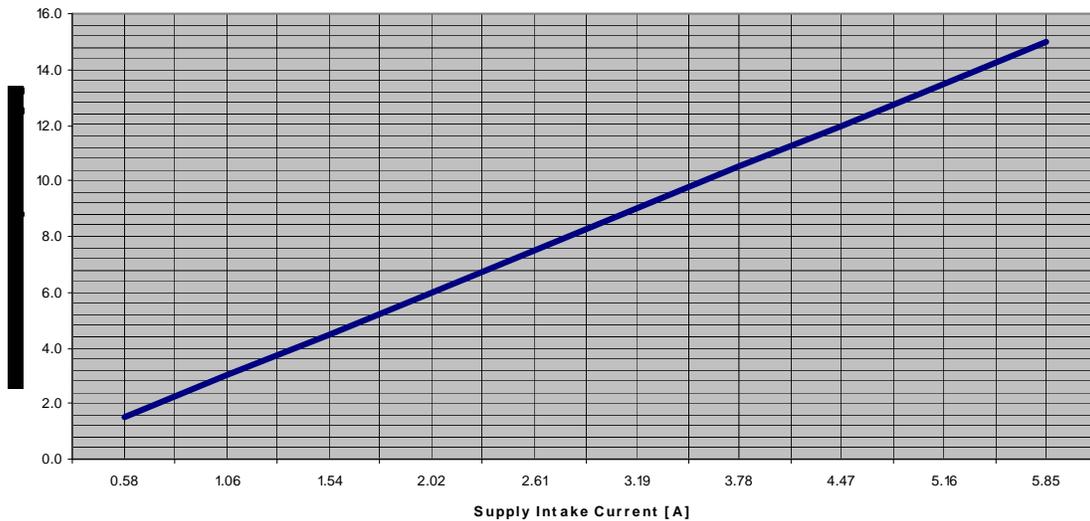
Supply Voltage vs Intake Current when all outputs ON at 1500 mA
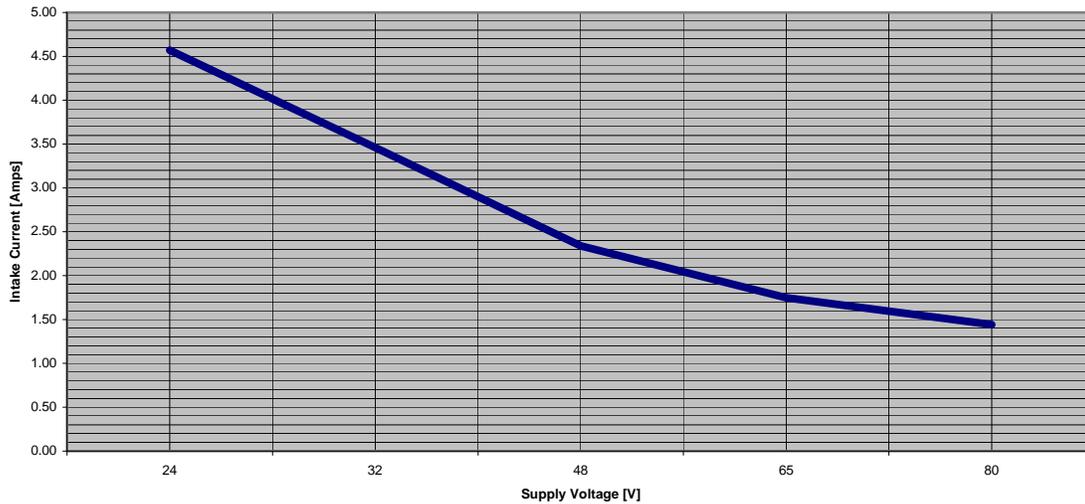
WARNING: The 9 outputs are user selectable from 0 to 2000 mA but the unit can only handle a maximum of 7A of controller power supply intake at one time. At no time should the total intake current of the controller exceed 7A due to the rating of the connector. Failure to do so will result in unpredictable damage to unit.

Input Specifications

CAN commands (no physical inputs available)	SAE J1939 {CANopen® (model AX020201)} There are eleven setpoints per channel that are associated with the J1939 command message that is received by the controller from the network bus. *Refer to the user manual for details.*

Output Specifications

Proportional Outputs	High side (sourcing) 9 outputs, 12 or 24V Each output is configurable up to 2A. The number of outputs ON at one time is limited by the rating of the Deutsch IPD contacts (pins on the connector). NB. The maximum total current draw permitted on the power supply input pins is 7 Amps @ 24VDC, at one time.
Output Type	The user can select between the following outputs. *Refer to Table 1.0.* **Output Disabled** **Proportional Current** (0…2A) **Hotshot Digital** (0…2A, 0…10000 mSec.) **On/Off Digital** (0…2A) **Proportional Voltage** (0…85V) **PWM Duty Cycle** (150Hz…5000Hz, 0 to 100%)
Output Adjustments	Digital Current: 0 to 2000 mA Hotshot Hold Time: 0 to 10000 ms Proportional Current: 0 to 2000 mA Proportional Voltage: 0 to 85V PWM Duty Cycle: 0 to 100% PWM Frequency: 150 Hz to 5000 Hz Ramp Up: 0 to 10000 ms Ramp Down: 0 to 10000 ms Dither Frequency: 50 to 400 Hz Dither Amplitude: 0 to 500 mA *For default settings, refer to the user manual.*

Control Logic	By default, any output on the controller uses a Proprietary B message to receive command messages to control the output, and to send feedback data to the network bus.
	There are twelve setpoints per channel that are associated with the output and how it responds.
	There are five setpoints per channel that are associated with the J1939 feedback message that can be sent by the ECU to the network bus.
	Refer to the user manual for details.
Current Feedback	The current feedback is sampled every 10ms. The repetition rate is user selectable as well as the type of filter that is applied to the measured data, before it is used in the PID control loop and/or sent to the bus. The available filters are: • Filter Type 0 = No Filter • Filter Type 1 = Moving Average • Filter Type 2 = Repeating Average
Protection	Overcurrent protection is provided. Short circuit protection is provided. NB. Outputs are separately protected against short circuits to both power and GND. If the current at the output exceeds 6A, the protection circuitry will shut off the output signal, regardless of what type of output mode had been selected for that channel.
Error Detection	The controller can detect and flag overcurrent and open circuit loads, which can be read via the J1939 network for diagnostic purposes.
Output Impedance	18-19 KOhms

Table 1.0 Output Types for AX021200

Type	Description
Output Disabled	The output channel is disabled, and will not respond to any messages from the bus. None of the other output setpoints apply.
Proportional Current	The controller regulates the current through a solenoid to precisely control the response of a proportional valve. The unit measures the current feedback, and uses it in a high-speed P-I-D loop to accurately set the current through the load. A high frequency signal (20kHz) is used to provide an output with low ripple. If required, a low frequency signal can be superimposed on the output to dither the load with adjustable frequency and amplitude.
	The output current will vary linearly with respect to the command signal received from the bus, with up to two slopes. *Refer to Figure 1.0.*
	Minimum, Breakpoint and Maximum currents can be set anywhere from 0mA to 2000mA. If a single slope is required, set the Breakpoint Output and Command setpoints equal to the Minimum setpoints. If an inverse response profile is required, simply set the Minimum Output higher than the Maximum Output. Command setpoints are limited by each other, in that the Minimum <= Breakpoint <= Maximum, so they will have to be adjusted in order.
	A feedback signal sent to the network will be sent as a WORD with a 1mA/bit resolution, and 0mA offset. The data in the message will be the current through the load, as measured by the controller.
	For error detection, if the absolute difference between the measured current and the target current is greater than or equal to 200mA, the controller will flag an error at the output. If the measured value is higher than the target, the controller flags an overcurrent; otherwise, it flags an open circuit at the load. These thresholds are not user configurable.
	Accuracy: +/-1% over the 2000 mA range
Hotshot Digital	In this mode, the output can be hotshot with a current to turn the load on, and then dropped to a holding current to keep the load on with less energy. For digital loads that have a high duty cycle, using this type of output can help improve the overall system efficiency. The current at which the output is hotshot, and the length of time it is held at this value, are both configurable setpoints, as is the holding current. *Refer to Figure 2.0.*
	In this mode, a command message less than or equal to the Off Threshold setpoint will turn the output off. A message greater than or equal to the On Threshold will turn the output on. Command message values between these two setpoints will have no affect on the state of the output.
	Dither, Breakpoint and Ramp setpoints do not apply in this mode. Feedback messages and error detection properties are the same as for proportional current outputs.
	Accuracy: +/-1% over the 2000 mA range

|	
On/Off Digital	In this mode, the output will either be off, or switched to the power supply voltage. The output will respond to changes in the command message the same way as for a hotshot digital response.
	A feedback signal sent to the network will be sent as a WORD with a 1mA/bit resolution, and 0mA offset. The data in the message will be the current through the load, as measured by the controller.
	For error detection, if the measured current at the load is less then 100mA, an open circuit will be flagged. If the current at the load is greater than or equal to 2500mA, an overcurrent will be flagged. These thresholds are not user configurable.
Proportional Voltage	The controller will adjust the duty cycle of the output PWM signal such that the average voltage from the pin will be the target voltage. The unit measures the power supply voltage, and uses it to calculate the required duty cycle of the output signal. Typically, a high frequency signal (20kHz) is used to provide an output that will have low ripple after filtering. External filtering will be required to turn this signal into a voltage output.
	Refer to Figure 1.0. The relationships between the Output setpoints and the Command setpoints are the same as with a current output. Up and down ramps would also apply in the same manner as with a current output. The Minimum, Breakpoint and Maximum voltages can be set anywhere from 0V to 85V.
	In this mode, a feedback signal sent to the network will be sent as a WORD with a 0.01V/bit resolution, and 0V offset. The data in the message will be the target output voltage, as calculated based on the response profile variables.
	For error detection, if the measured current at the load is less then 100mA, an open circuit will be flagged. If the current at the load is greater than or equal to 2500mA, an overcurrent will be flagged. These thresholds are not user configurable.
	Accuracy: +/-5% average of the actual output voltage with respect to the target commanded voltage.
PWM Duty Cycle	In this mode, the controller will adjust the duty cycle of the output PWM signal. *Refer to Figure 1.0.*
	The relationships between the Output setpoints and the Command setpoints are the same as with a current output. Up and down ramps would also apply in the same manner as with a current output. The Minimum, Breakpoint and Maximum duty cycles can be set anywhere from 0% to 100%.
	Any output configured for a duty cycle response will have a setpoint available that will allow the user to adjust the frequency of the output signal. However, there are several restrictions for this parameter as listed below.
	a. Certain channels always have the same frequency for the output signal. This means that if any one of these channels is configured for a current output (proportional or hotshot), the PWM Frequency setpoint will be ignored, and the output frequency will always be 20kHz. The output channels that share a frequency are channels 1 to 6, and channels 7 to 9 respectively. If both current and PWM output types are required, they will have to be split between those two groups in order for the controller to perform as expected.
	b. If condition (a) has been met (no current output in that group of channels), then the frequency that will be used for the group will be of the output channel with the LOWEST index number that has been configured as a PWM duty cycle output, and has a non-zero entry in this setpoint. This parameter will be ignored for all the other channels.
	c. The new PWM frequency will NOT take effect until the unit has been reset by cycling the power.
	In this mode, a feedback signal sent to the network will be sent as a WORD with a 0.01 %dc/bit resolution, and 0%dc offset. The data in the message will be the target output duty cycle, as calculated based on the response profile variables.
	For error detection, if the measured current at the load is less then 100mA, an open circuit will be flagged. If the current at the load is greater than or equal to 2500mA, an overcurrent will be flagged. These thresholds are not user configurable.
	Accuracy: +/- 1.15% average

Output Response Profiles:
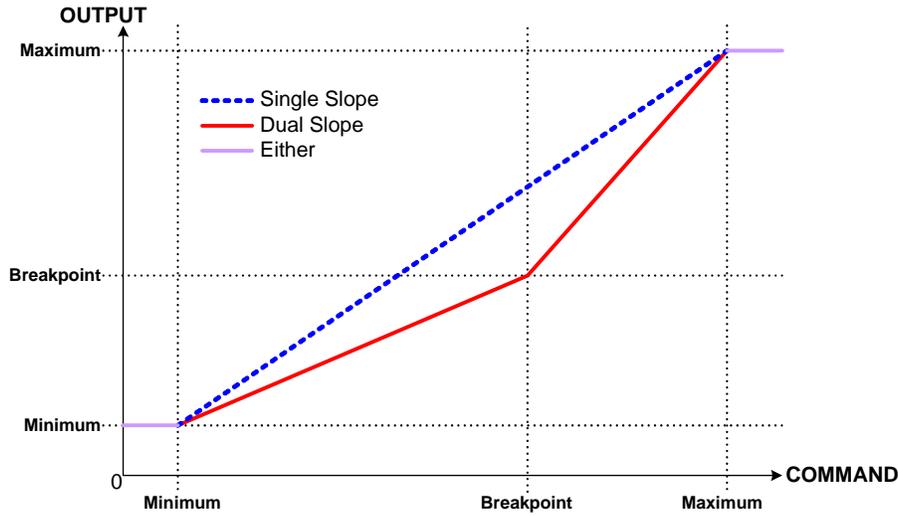
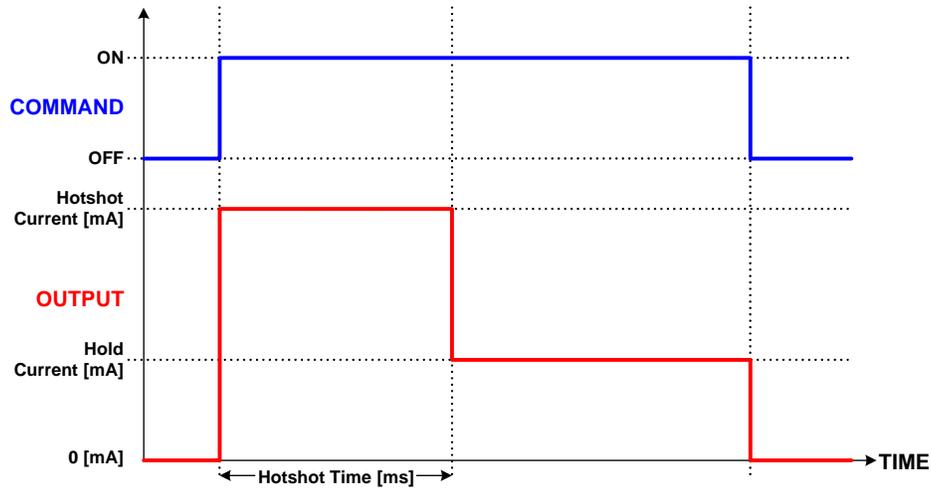*Figure 1 – Proportional Output vs. Command Profile*

Figure 2 –Hotshot Digital Profile

General Specifications

Microprocessor	DSP56F8346
Efficiency	85.5%@24V, 89.2% over entire voltage range *Refer to Figure 3.0.*
Control Logic	Standard embedded software. Refer to the user manual for details. *Application-specific software is available on request.*
Communications	1 CAN port (2.0B, SAE J1939) CANopen® (model AX021201) and other CAN based protocols available on request 1 RS-232 port
User Interface	User configuration and diagnostics are provided with the Axiomatic Electronic Assistant®. The Axiomatic Service Tool is a *Windows*-based graphical user interface that allows easy configuration of the controller setpoints. *Refer to Table 3.0 for details.*
Network Termination	It is necessary to terminate the network with external termination resistors. The resistors are 120 Ohm, 0.25W minimum, metal film or similar type. They should be placed between CAN_H and CAN_L terminals at both ends of the network.

Input vs Output Power vs Efficiency

Number of Outputs ON

Legend:
— Supply Input Power [W]
— Total Output Power [W]
— Efficiency [%]
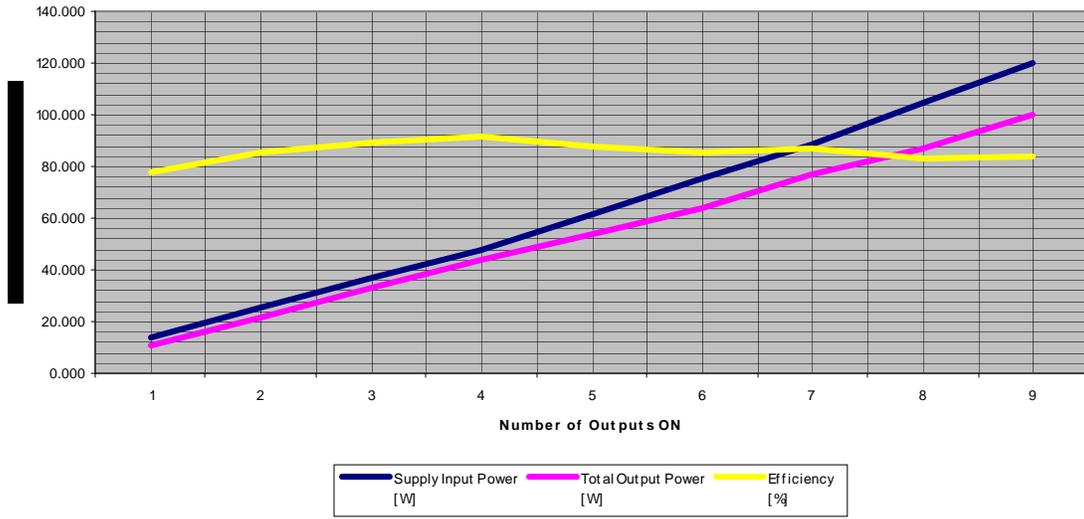
Input vs Output Power and Efficiency over 20-80V range

Supply Voltage [V]

Legend:
— Input Power
— Output Power
— Efficiency
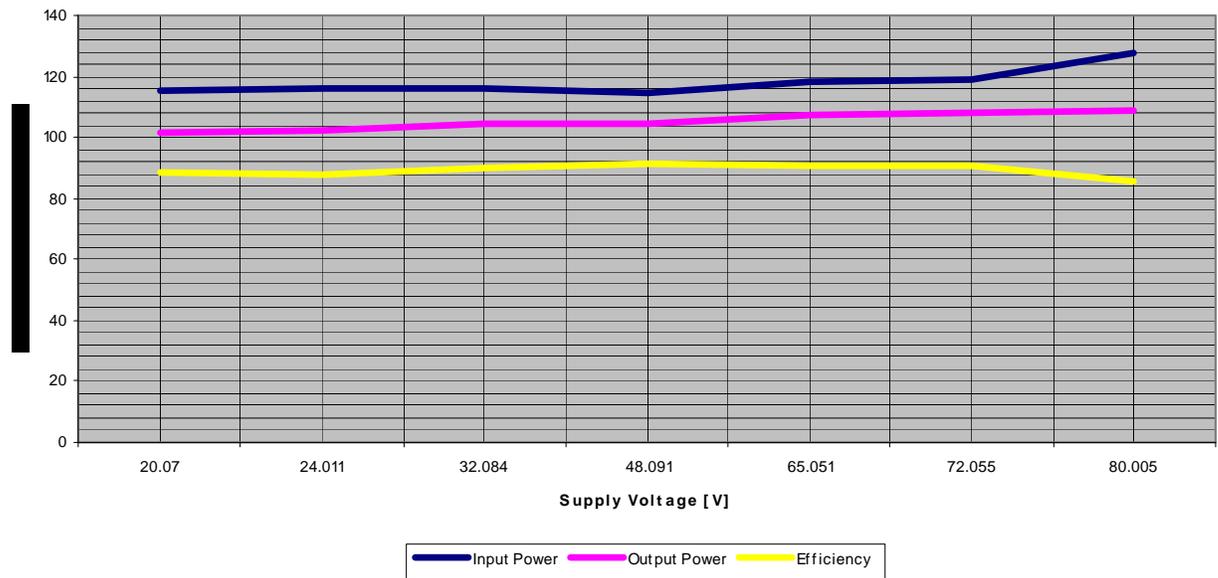
Figure 3.0 – Efficiencies

CAN Interface	1 CAN port (SAE J1939)
	The software was designed to provide flexibility and provides the following.
	• Configurable ECU Instance in the NAME (for multiple ECU's on the network)
	• Configurable Input Parameters
	• Configurable Output Parameters
	• Configurable PGN and Data Parameters
	• Configurable Diagnostic Messaging Parameters, as required
	• Diagnostic Log, maintained in non-volatile memory
	Note: Configurable parameters are also called setpoints.
	There are ten setpoints per channel that are associated with the J1939 command message that is received by the ECU from the network bus. There are setpoints used with both output and fault channels. *To use J1939, refer to the user manual.*
	The Axiomatic AX021200 is compliant with Bosch CAN protocol specification, Rev.2.0, Part B, and the following J1939 standards.

Table 2: J1939 Compliance

OSI Network Model Layer	J1939 Standard
Physical	J1939/11 – Physical Layer, 250K bit/s, Twisted Shielded Pair. J1939/15 - Reduced Physical Layer, 250K bits/sec, Un-Shielded Twisted Pair (UTP).
Data Link	J1939/21 – Data Link Layer
	The controller supports Transport Protocol for Diagnostic DM1 and DM2 messages (PGN 65226 and 65227). It supports responses on PGN Requests (PGN 59904) and acknowledgements (PGN 59392). It also supports Proprietary B messaging (PGN 65280 to 65535), and uses a proprietary scheme described in the User Manual.
Network Layer	J1939/81 – Network Management J1939, Appendix B – Address and Identity Assignments
	Arbitrary Address Capable ECU - It can dynamically change its network address in real time. The controller supports: Address Claimed Messages (PGN 60928), Requests for Address Claimed Messages (PGN 59904) and Commanded Address Messages (PGN 65240).
Application Layer	J1939/71 – Vehicle Application Layer
	None of the application layer PGN's are supported as part of the default configurations. However, the controller could be configured such that any of the input messages to be sent will use a PGN from this section, or for the outputs to respond to the data in a message with a PGN from this section. The data size, index, resolution and offset can all be configured for the appropriate SPN associated with the PGN. *It is the user's responsibility to configure the controller such that it will not violate the J1939 standard.*
	J1939/73 – Application Layer – Diagnostics
	The controller can be configured to send "Active Diagnostic Trouble Code" DM1 messages (PGN 65226) for any I/O channel. Warning and Protect diagnostics will automatically become previously active when cleared. "Previously Active Diagnostic Trouble Codes" DM2 messages (PGN 65227) are available on request. Shutdown diagnostics will be cleared upon receiving a "Diagnostic Data Clear/Reset for Active DTC's" DM11 message (PGN 65235). Occurrence counts in the diagnostic log will be cleared upon receiving a "Diagnostic Data Clear/Reset for Previously Active DTC's" DM3 message (PGN 65228).

Diagnostics – CAN Network	Each output channel can be configured to send diagnostic messages to the network if the load goes out of range. There are four setpoints per output channel, and ten per fault channel, that are associated with if and how diagnostic messages will be sent to the network bus. Alternatively, if the Axiomatic Proprietary B scheme is used, the status byte of the feedback message could be used to recognize an error at the output. How the controller detects a fault for a channel will depend on the output type. In addition to the output channels, three other types of fault channels can be reported to the network using diagnostic messaging. They are Over Temperature (of the processor), Over Voltage and Under Voltage (of the power supply). *Refer to the user manual for details.*

RS-232	The RS-232 interface can be used to changes some setpoints during set up. It also provides the tools for troubleshooting and debugging the controller. For example, how much current is being sourced from an output is available from this port as is the microprocessor's temperature. It can also be used to verify that the CAN commands are truly assigning an output as ON or OFF. *For more detailed information please refer to the User Manual.*

Table 3.0 - AX070500 Electronic Assistant

Electronic Assistant® EA

The Electronic Assistant (EA) runs on any modern PC with the Microsoft Windows® 2000 operating system or higher. It comes with a royalty-free license for use.

System Requirements:
Operating System: *Windows* 2000 or higher including 64-bit editions

Port: USB 1.1 or 2.0 full speed

Display: VGA (XGA or better with 1024 x 768 recommended)

Setup and Configuration:
Refer to the User Manual UMAX07050X.

To order the EA software at the time of initial purchase, order the KIT AX070502 (see above) which includes the Axiomatic USB-CAN converter. For additional EA and USB-CAN software ONLY CD's, use ordering P/N: CD-AX070502.
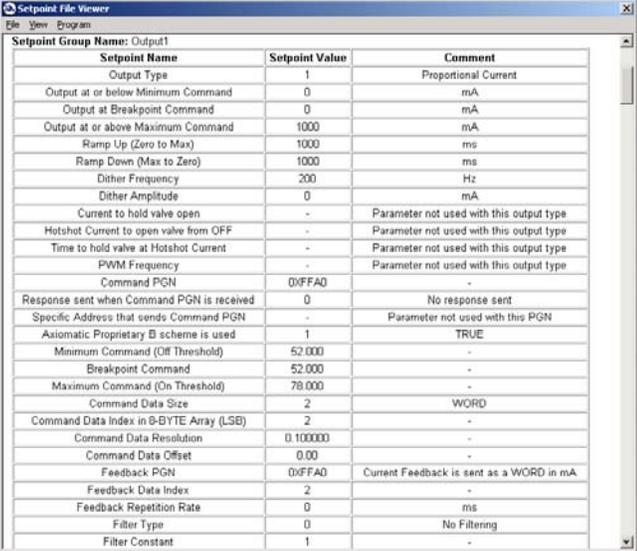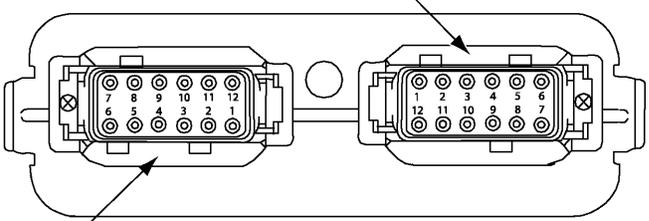

Figure 4.0 Configuration screen from the Electronic Assistant

The Electronic Assistant® (EA) is a software configuration tool that runs on a PC connected to a J1939 bus via a USB to CAN converter, AX070501. Upon being connected to the bus, the EA will find all the Electronic Control Units (ECU) on the bus, and recognized those manufactured by Axiomatic. Using this tool, a user can quickly configure an Axiomatic ECU for the desired performance over a wide variety of applications.

Electrical Connections	Deutsch DTM series 24 pin receptacle (DTM13-12PA-12PB-R008) Mating plug: Deutsch DTM06-12SA and DTM06-12SB with 2 wedgelocks (WM12S) and 24 contacts (0462-201-20141). 20 AWG wire is recommended for use with contacts 0462-201-20141. **Use dielectric grease on the pins when installing the controller.**

Key Arrangement B (black)

Key Arrangement A (grey)

FRONT VIEW 24 PIN RECEPTACLE

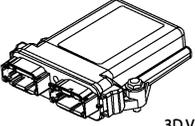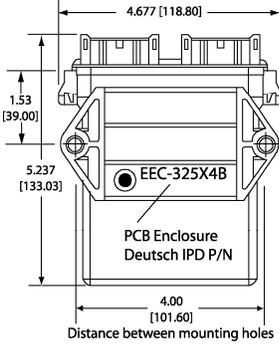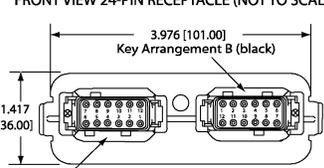*Refer to Table 4.0 for the pin out.*

Packaging and Dimensions	High Temperature Nylon housing - Deutsch IPD PCB Enclosure (EEC-325X4B) 4.62 x 5.24 x 1.43 inches 117.42 x 133.09 x 36.36 mm (W x L x H excluding mating plugs) **HOUSING DIMENSIONS** Housing Material: High Temperature Nylon (Black) 3D VIEW Housing with 24 Pin Receptacle 4.677 [118.80] Height 1.368 [34.75] with 24 pin receptacle 1.53 [39.00] 5.237 [133.03] EEC-325X4B Mounting Holes: ø 0.29 [7.40] through 2 pl for 0.25 [6.00] fastener PCB Enclosure Deutsch IPD P/N Mounting flange: 16 mm [0.63 in] thick 4.00 [101.60] Distance between mounting holes BOTTOM VIEW FRONT VIEW 24-PIN RECEPTACLE (NOT TO SCALE) 3.976 [101.00] Key Arrangement B (black) 1.417 [36.00] Key Arrangement A (grey) Mating Plug Assemblies for 24-pin receptacle: Deutsch IPD P/N: DTM06-12SA and DTM06-12SB with wedgelocks WM12S and contacts (Contact factory for contact specification.) Dimensions: inches [mm] excluding mating plug(s)
Operating Conditions	-40 to 70°C (-40 to 158°F) with **all** 9 outputs ON at 1.5A -40 to 85°C (-40 to 185°F) with **less than** 9 outputs ON at 1.5A
Weight	0.60 lbs. (0.27 kg)
Protection	IP67, Unit is conformally coated in the housing. Plugs carry an IP69 rating.

Table 4.0 – Pin out: AX021200

Grey Connector		Black Connector	
Pin #	Function	Pin #	Function
1	Ground 5	1	Output 6
2	Ground 4	2	Output 7
3	Ground 3	3	Output 8
4	Ground 2	4	Output 9
5	Ground 1	5	RS232 TXD (Not Used)
6	BATT -	6	CAN HI
7	BATT +	7	CAN LO
8	Output 1	8	RS232 RXD (Not Used)
9	Output 2	9	Ground 9
10	Output 3	10	Ground 8
11	Output 4	11	Ground 7
12	Output 5	12	Ground 6

Note: CANopen® is a registered community trade mark of CAN in Automation e.V.

Specifications are indicative and subject to change. Actual performance will vary depending on the application and operating conditions. Users should satisfy themselves that the product is suitable for use in the intended application. All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/Limitations and Return Materials Process as described on www.axiomatic.com/service.html.

Form: TDAX021200- 07/20/09